US009471166B2

(12) **United States Patent**
Sekiguchi

(10) **Patent No.: US 9,471,166 B2**
(45) **Date of Patent: Oct. 18, 2016**

(54) **TOUCH PANEL AND LIQUID CRYSTAL DISPLAY DEVICE HAVING THE TOUCH PANEL**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/454,814**

(22) Filed: **Aug. 8, 2014**

(65) **Prior Publication Data**

US 2015/0042909 A1 Feb. 12, 2015

(30) **Foreign Application Priority Data**

Aug. 9, 2013 (JP) 2013-165819

(51) **Int. Cl.**
G06F 3/041 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 3/0412*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 3/041
USPC 345/173
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0291966 A1 12/2011 Takao et al.
2012/0062250 A1* 3/2012 Kuo G06F 3/044 324/686
2012/0228110 A1* 9/2012 Takahashi G06F 3/044 200/600
2013/0069069 A1* 3/2013 Koo G02F 1/136227 257/59
2013/0093706 A1* 4/2013 Kurasawa G06F 3/0412 345/173
2014/0063370 A1* 3/2014 Ko H05K 1/0274 349/12

FOREIGN PATENT DOCUMENTS

JP 2011-248722 A 12/2011

* cited by examiner

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(57) **ABSTRACT**

A touch panel includes plural scanning electrodes, plural detection electrodes that are formed to intersect with the plural scanning electrodes, one or a plurality of layers being disposed between the plural detection electrodes and the plural scanning electrodes, plural holes that are arrayed apart from each other on each of the plural detection electrodes, and shaped into polygons each shaped to have five or more corners in a plan view, and plural dummy electrodes that are formed between the respective adjacent detection electrodes, made of the same material as that of the detection electrode, and electrically isolated from each other, in which the plural dummy electrodes are shaped into the polygons in a plan view.

14 Claims, 12 Drawing Sheets

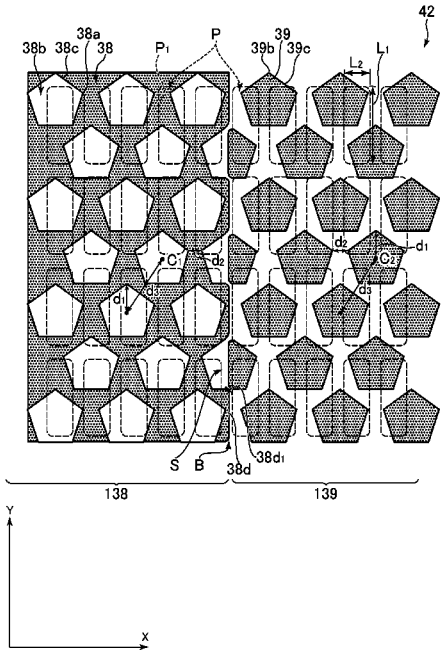
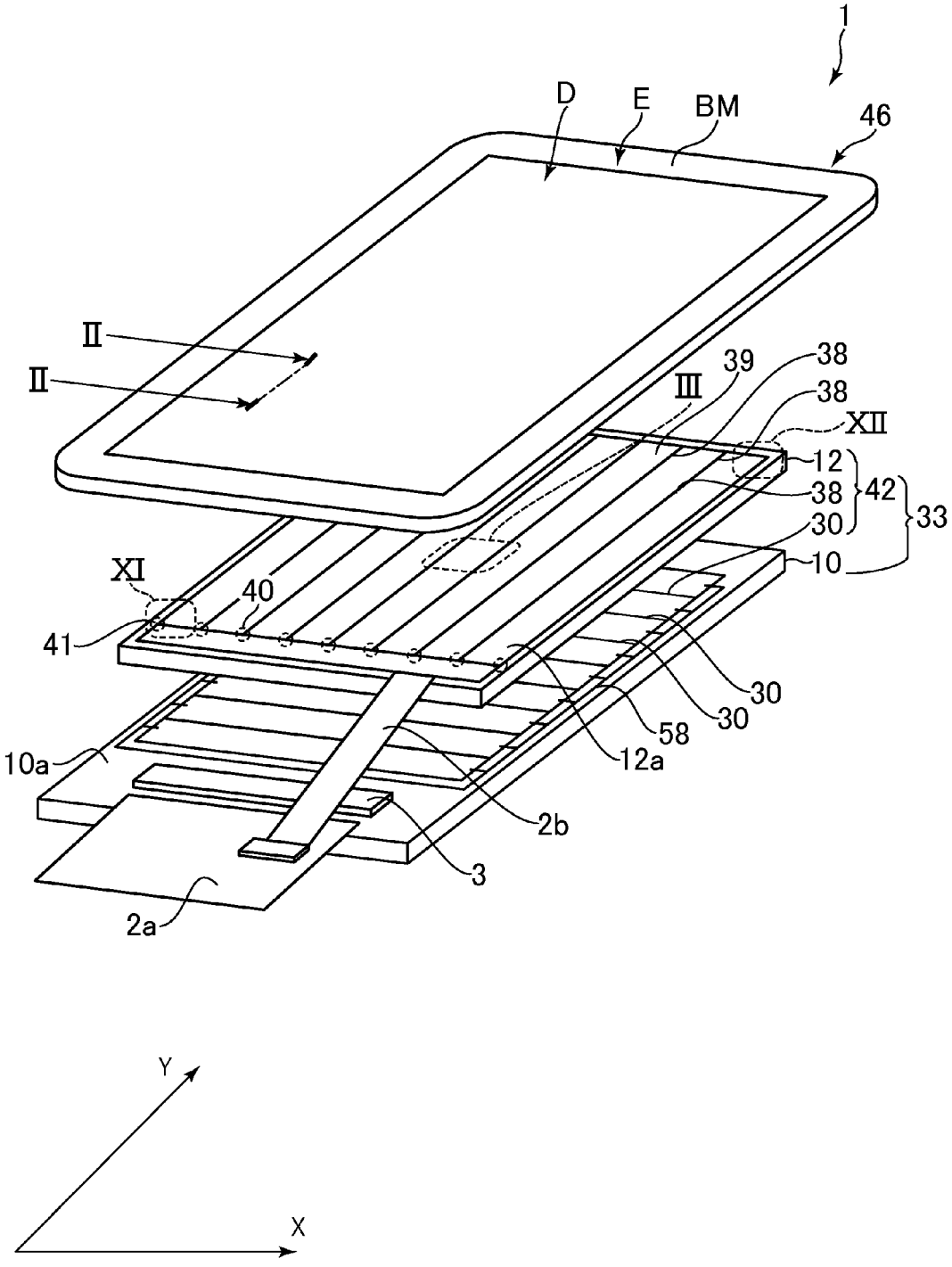


FIG.1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2b
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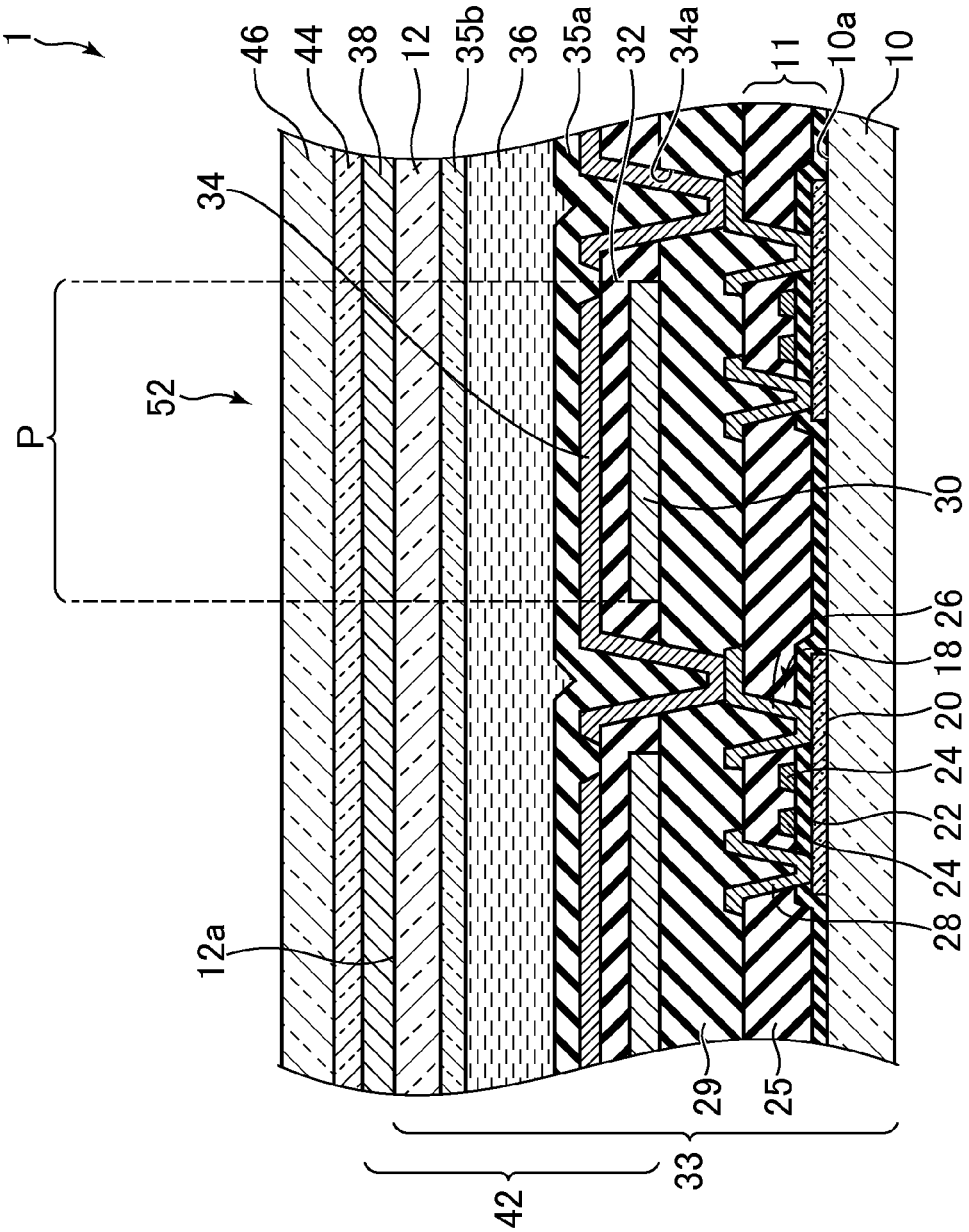
2a
Y
X

FIG.2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34a
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10a
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28
12a
29
25
33
42

FIG.3

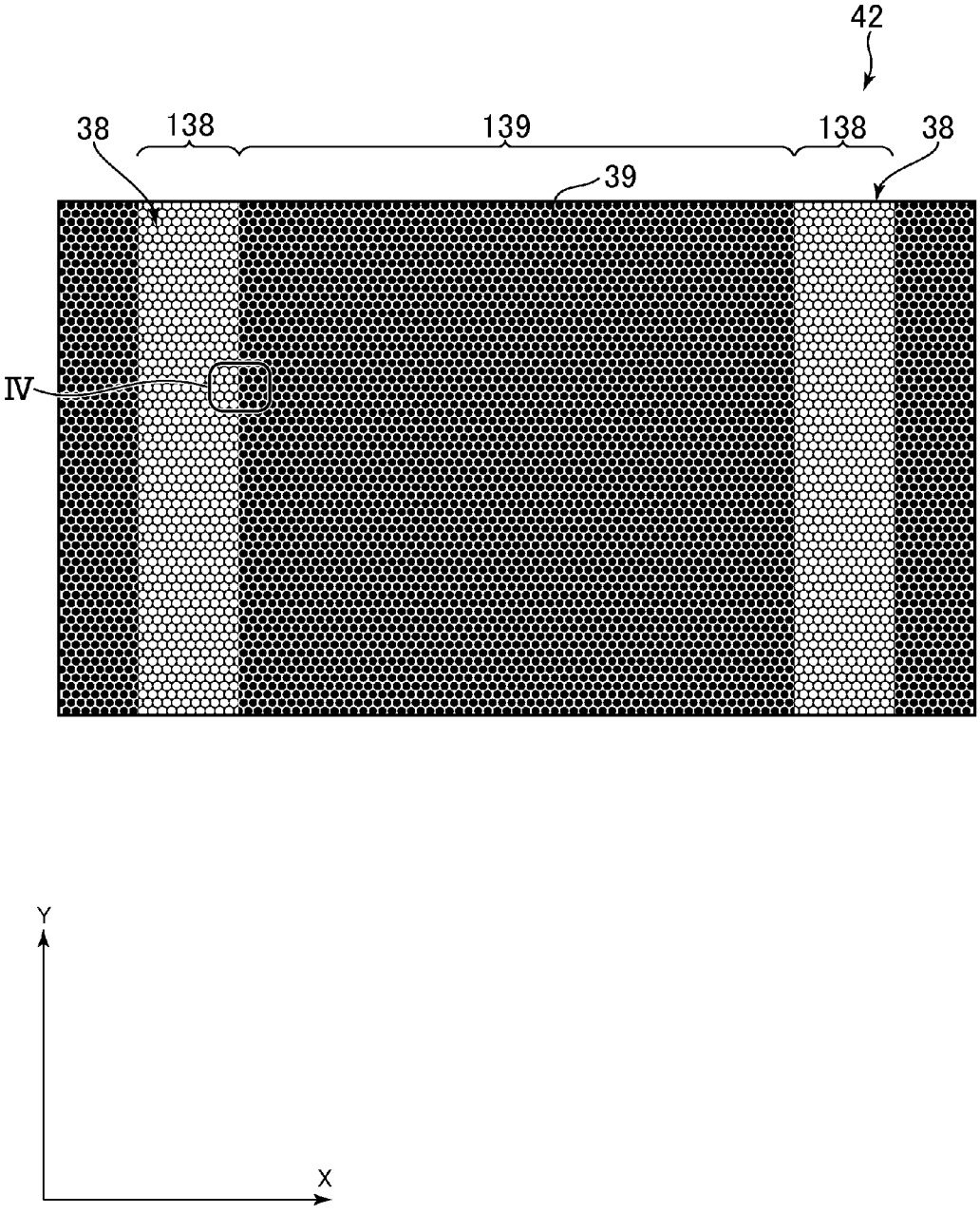
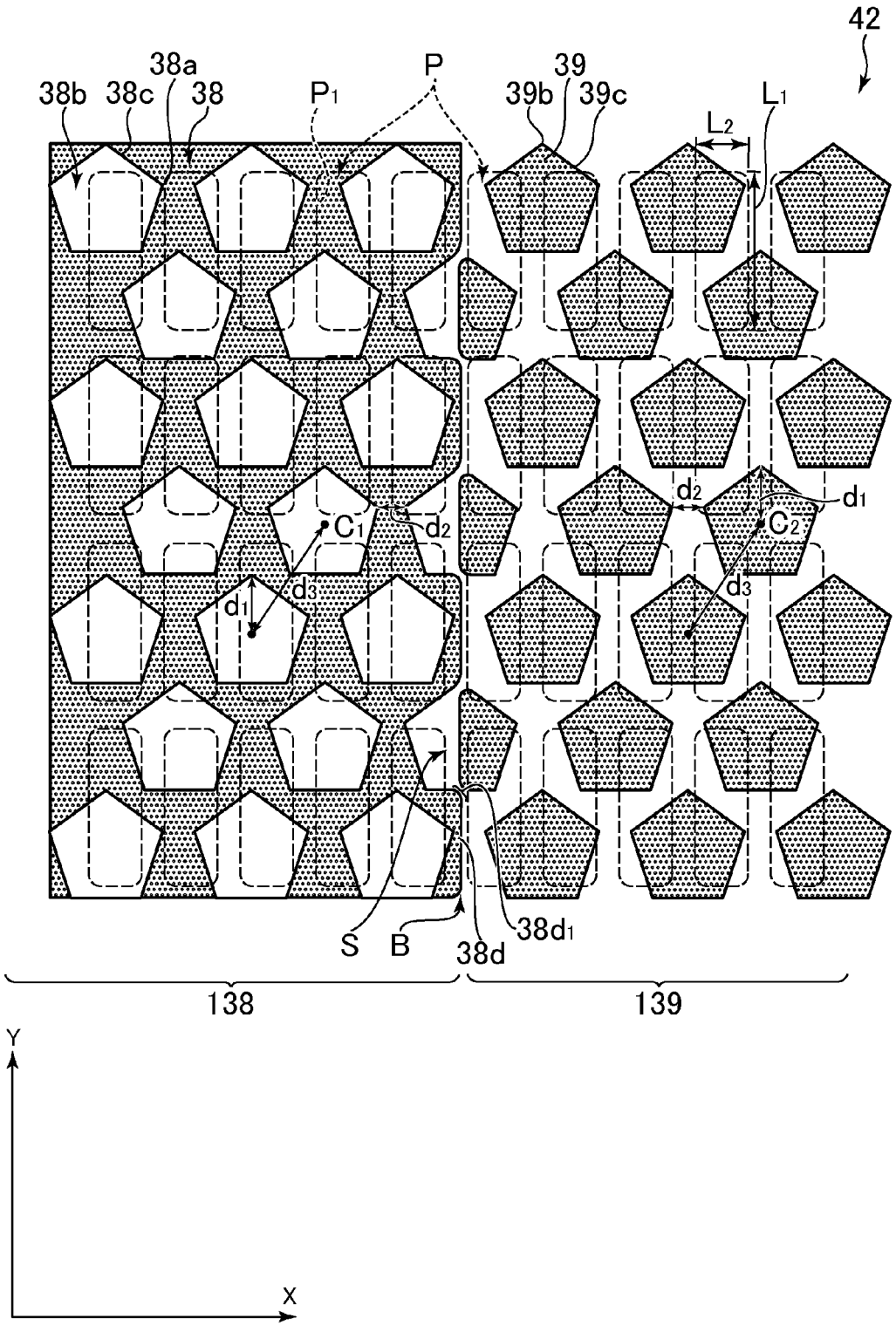


FIG.4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38a
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38c
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P1
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39b
39c
L1
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d2
d1
C1
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d1
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B
38d
38d1
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139
Y
X

FIG.5

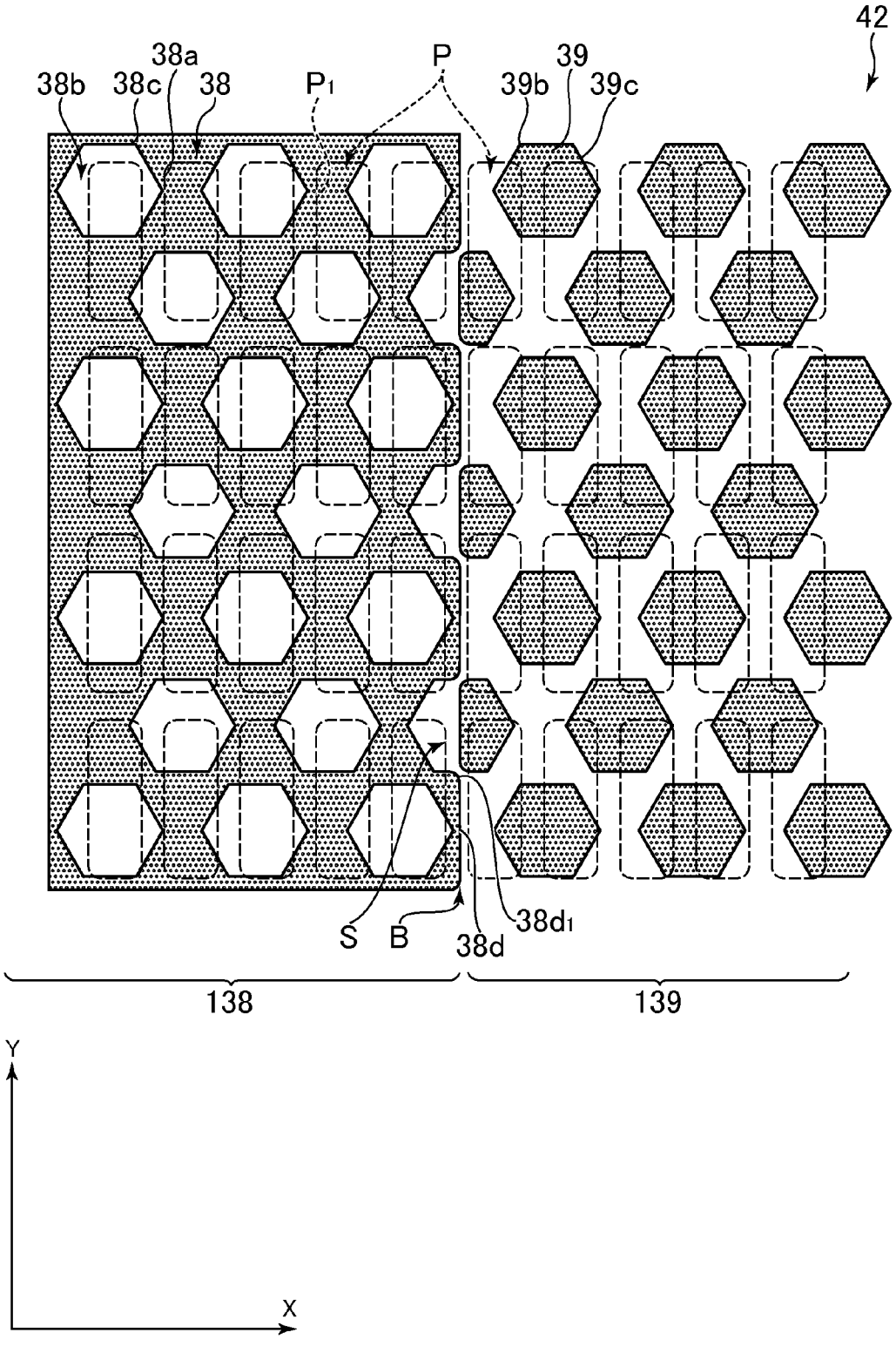


FIG.6

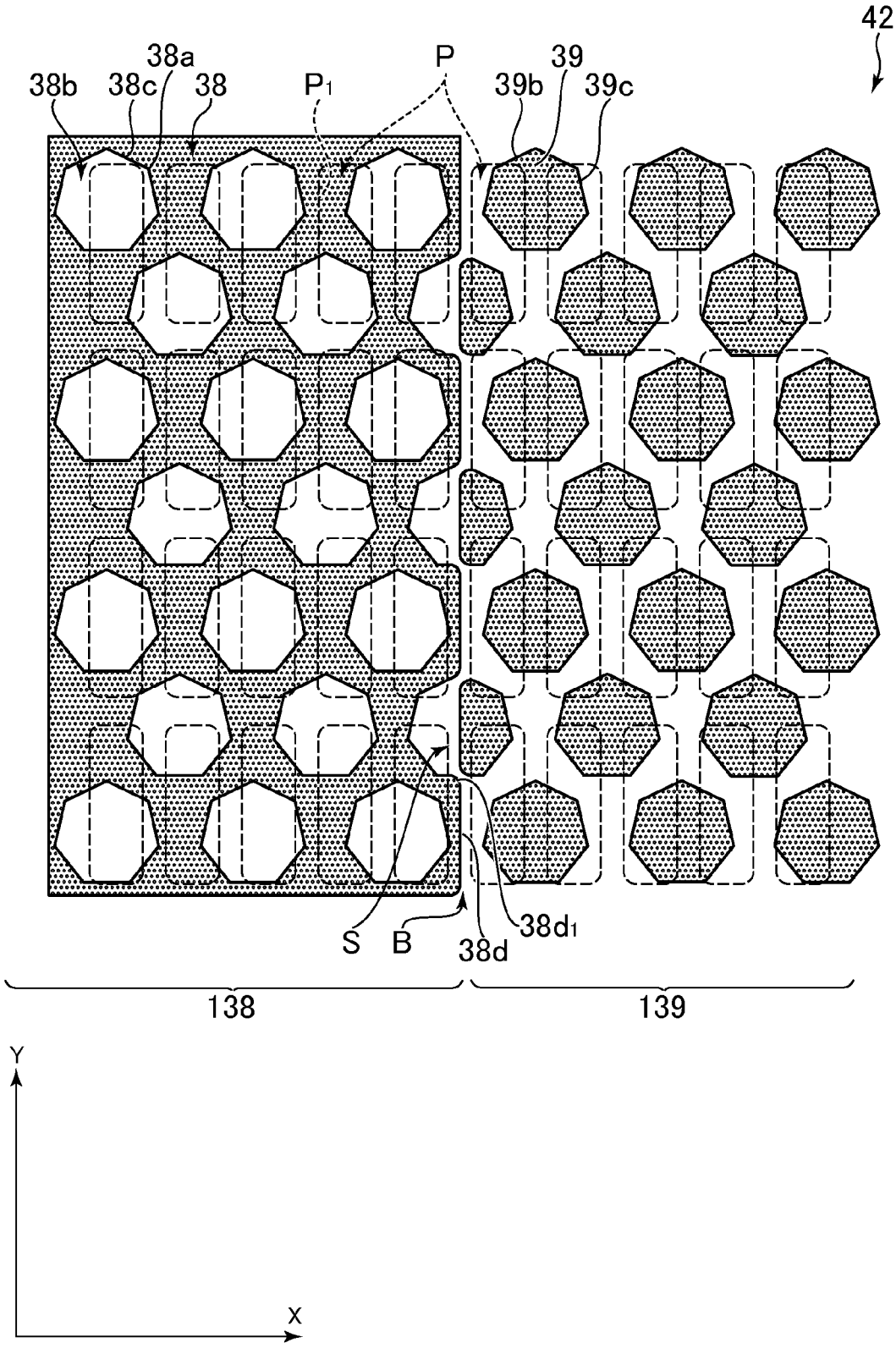
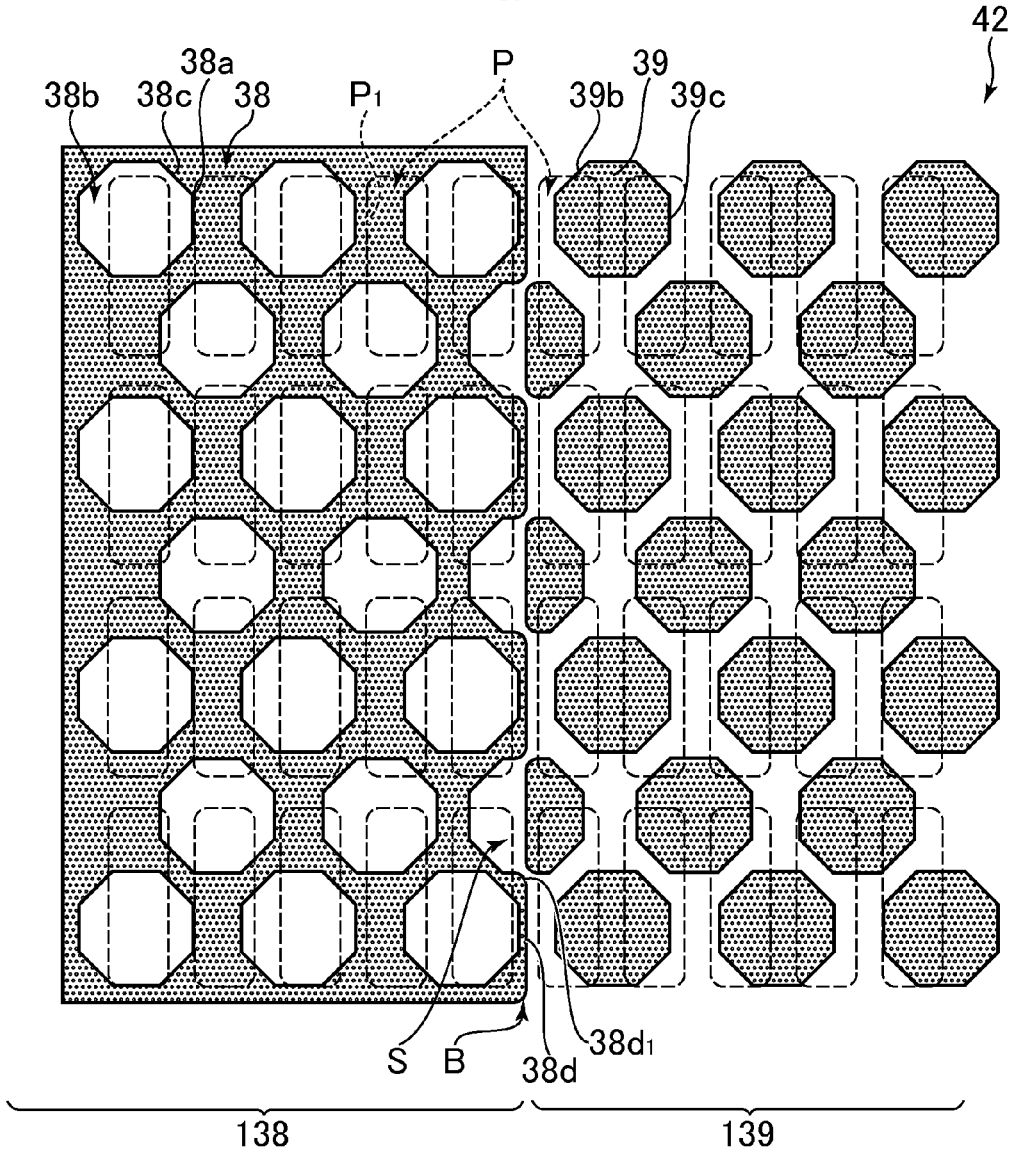


FIG. 7



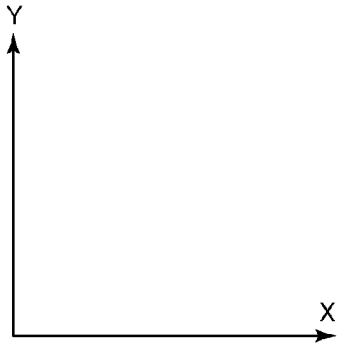
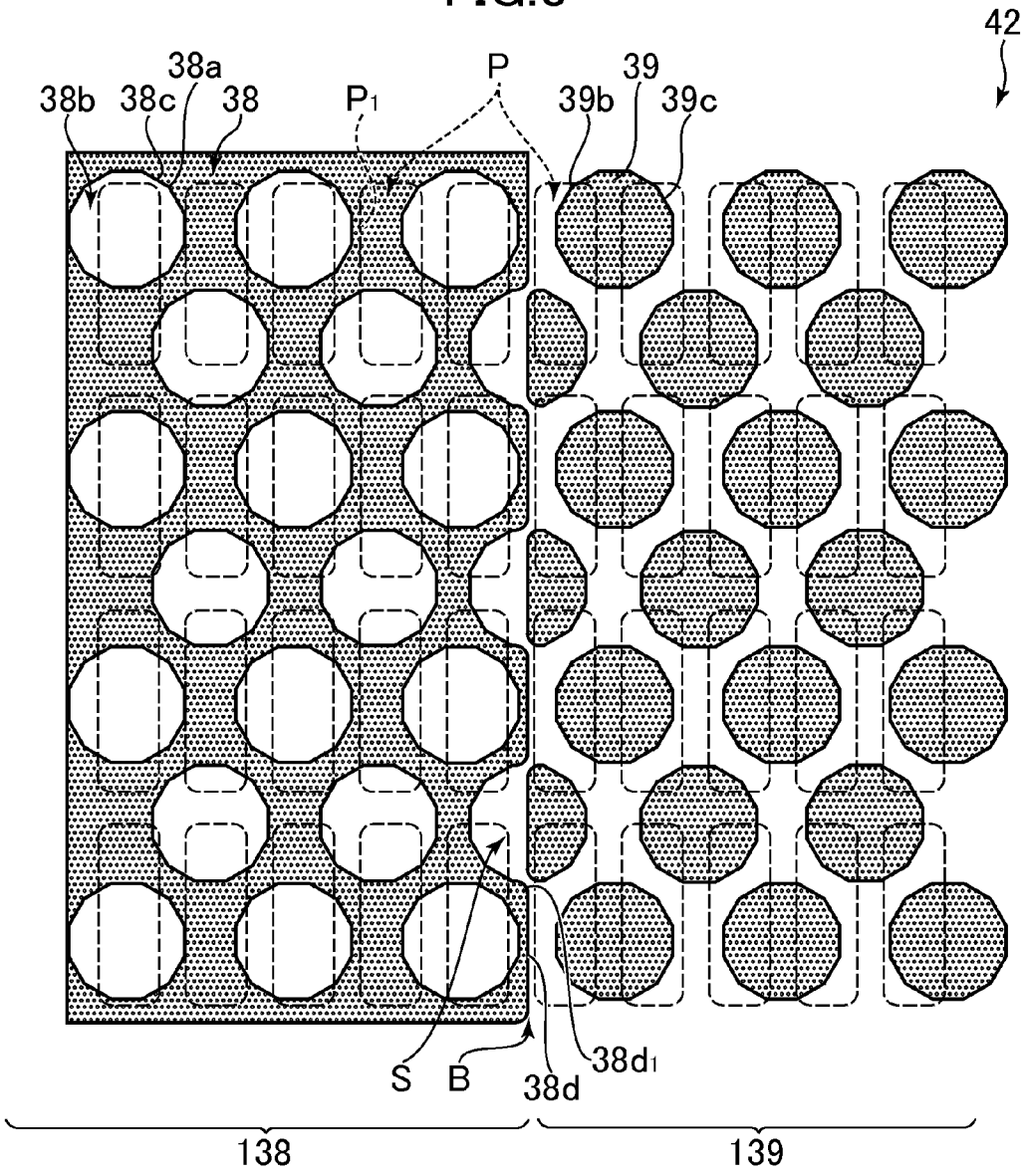


FIG.8



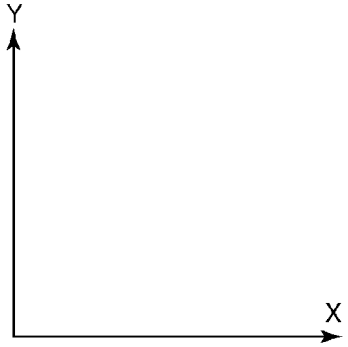


FIG.9

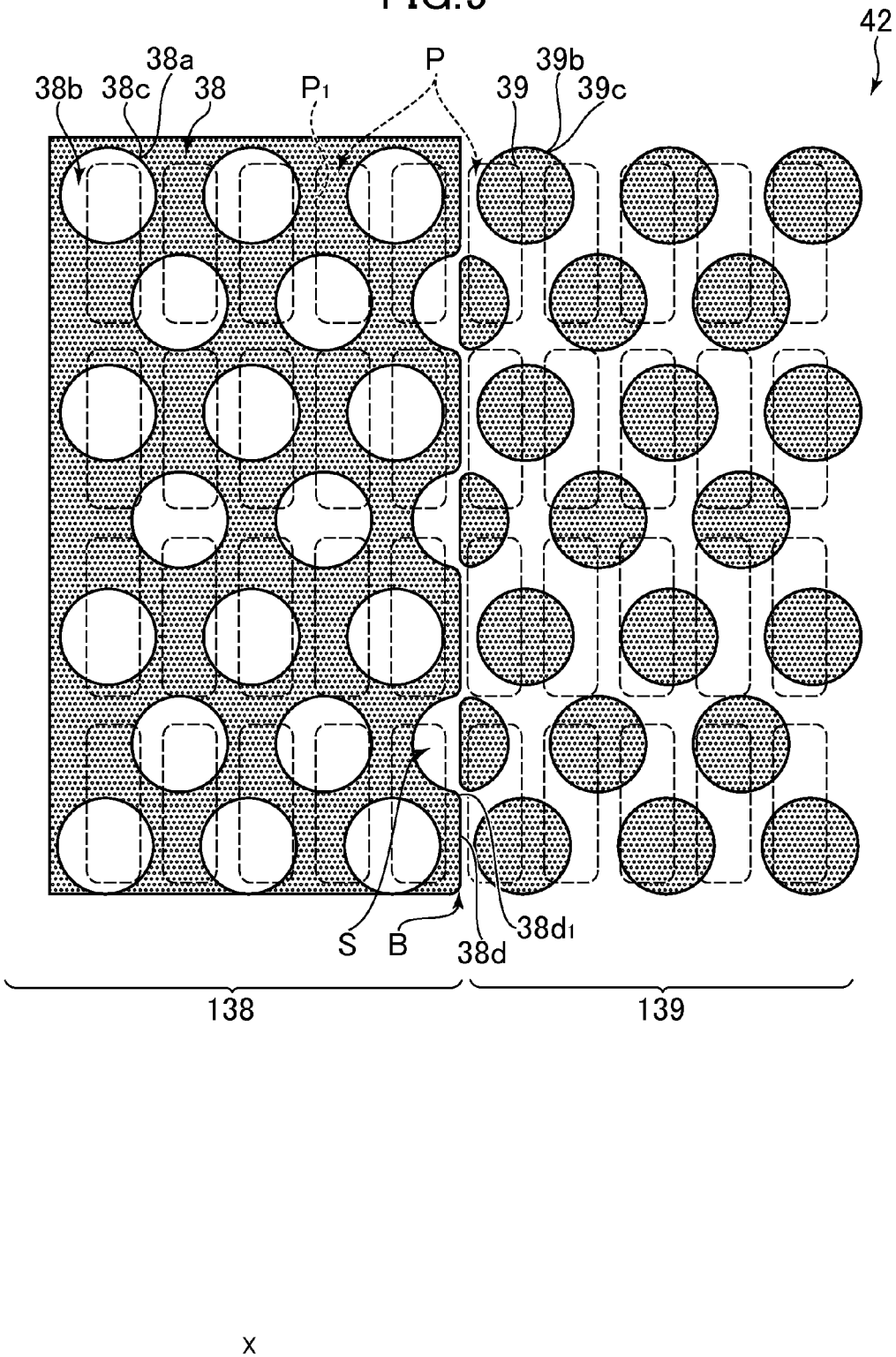


FIG.10

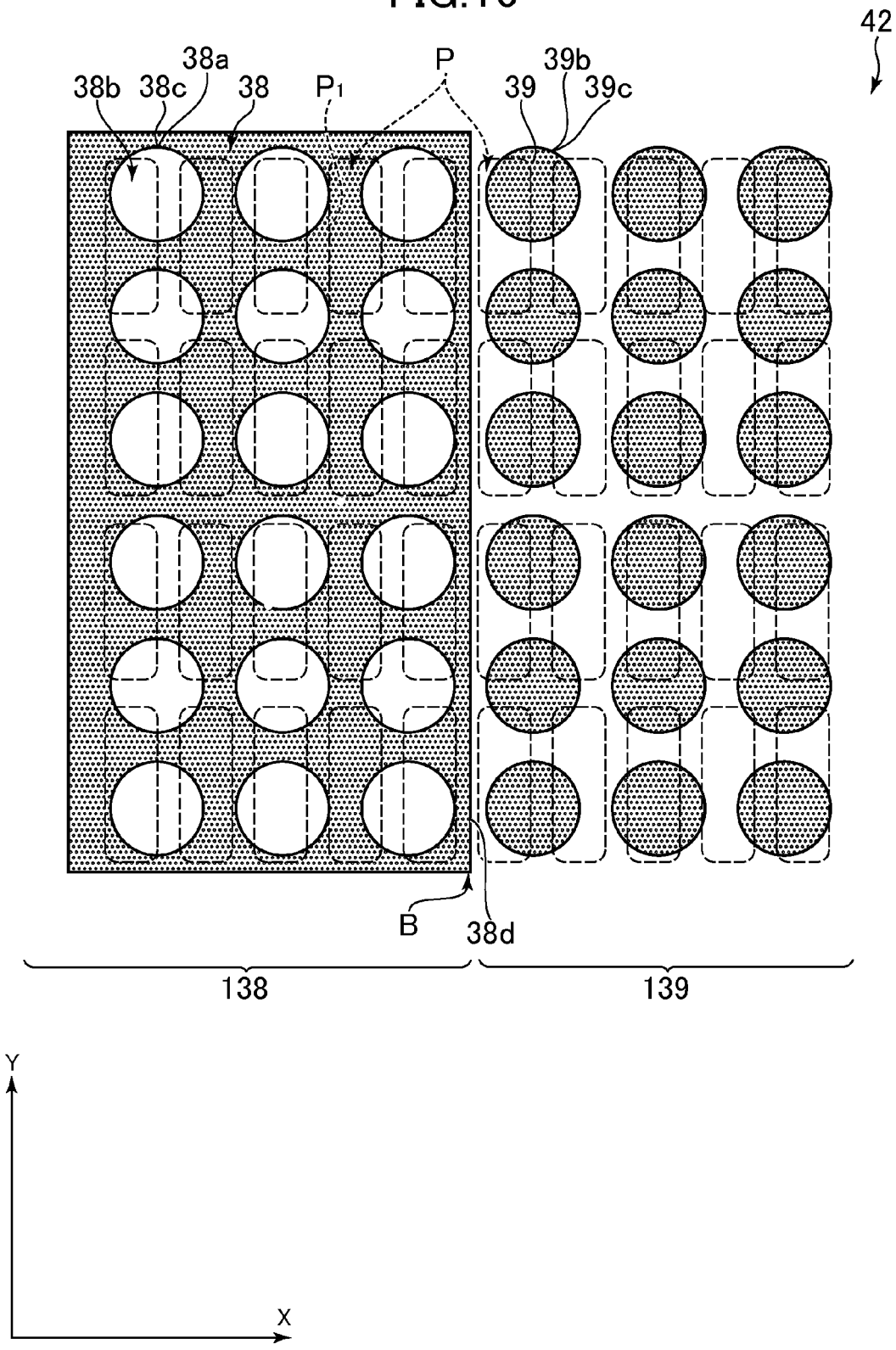
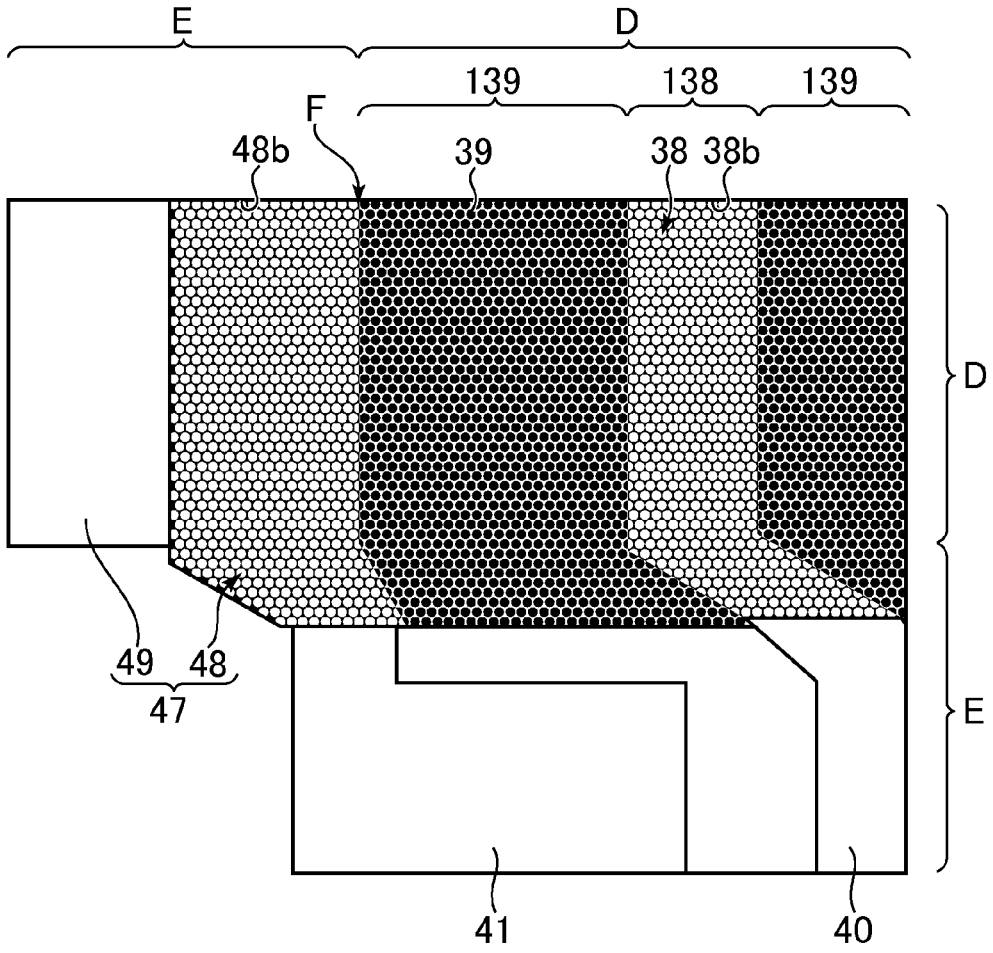


FIG.11



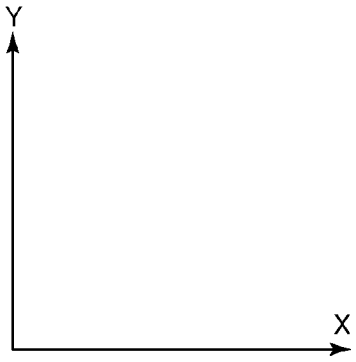
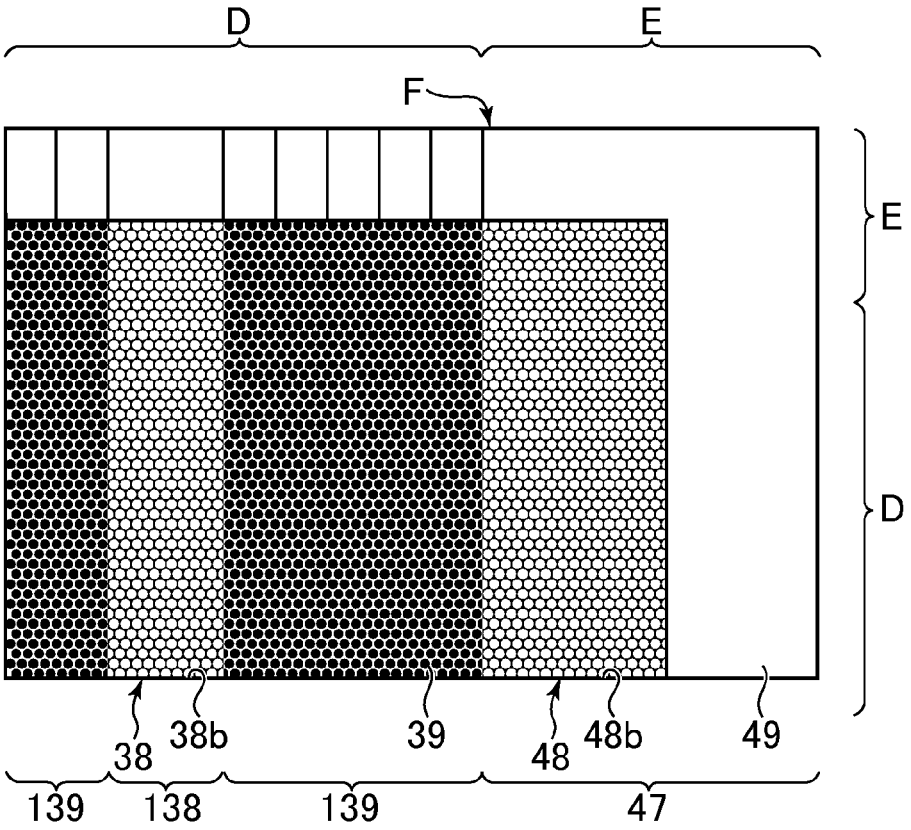
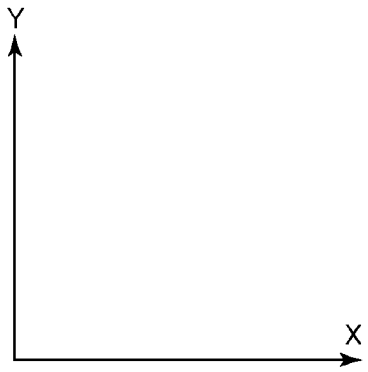


FIG.12





TOUCH PANEL AND LIQUID CRYSTAL DISPLAY DEVICE HAVING THE TOUCH PANEL

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims priority from Japanese application JP2013-165819 filed on Aug. 9, 2013, the content of which is hereby incorporated by reference into this application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a touch panel and a display device having the touch panel.

2. Description of the Related Art

In recent years, a touch panel that detects a position which is touched with a finger, a dedicated pen or the like has been developed. As the touch panel of this type, for example, a capacitance type touch sensor has been known which detects a change in capacitance of a portion that is subjected to a touch pressing operation (hereinafter referred to as "touch"). In a touch panel of an in-cell touch panel in which common electrodes in a liquid crystal display panel of an IPS (In-Plane Switching) system are used as scanning electrodes for touch detection, the scanning electrodes, and detection electrodes that intersect with the scanning electrodes are arranged in a matrix.

JP 2011-248722 A discloses a touch panel having diamond lattice-shaped detection electrodes in which plural conductor lines lined up in parallel intersect with each other at a given angle. In the touch panel of this type, first electrodes which are the scanning electrodes, and second electrodes which are the detection electrodes intersect with each other at a given angle so that conductor lines forming the first electrodes and the second electrodes configure square mesh patterns in a plan view.

SUMMARY OF THE INVENTION

In the touch panel disclosed in JP 2011-248722 A, because the plural conductor lines are lined up in parallel, side surfaces of the plural conductor lines reflect light in the same direction due to light emission from pixels. As a result, the pattern of the detection electrodes is visible from an outside of the display device. Also, in the display device disclosed in JP 2011-248722 A, because the square mesh patterns are successively adjacent to each other, interference fringes (hereinafter referred to as "moiré") in which halftone dots that are fine patterns successively appear cannot be prevented. This results in a risk that the visibility of an image to be displayed through the touch panel is deteriorated.

The present invention has been made in view of the above circumstances, and therefore aims at preventing the visibility of the image displayed through the touch panel from being deteriorated.

(1) According to the present invention, there is provided a touch panel, including: a plurality of scanning electrodes; a plurality of detection electrodes that are formed to intersect with the plurality of scanning electrodes, one or a plurality of layers being disposed between the plurality of detection electrodes and the plurality of scanning electrodes, a plurality of holes that are arrayed apart from each other on each of the plurality of detection electrodes, and shaped into polygons each shaped to have five or more corners in a plan view; and a plurality of dummy electrodes that are formed between the respective adjacent detection electrodes, made of the same material as that of the detection electrode, and electrically isolated from each other, in which the plurality of dummy electrodes are shaped into the polygons in a plan view.

(2) According to the present invention, in the touch panel according to the item (1), the plurality of holes shaped into the polygons and arrayed on the detection electrodes, and the plurality of dummy electrodes may form a uniform contiguous array.

(3) According to the present invention, in the touch panel according to the item (1) or (2), the planar view shape of the polygons may be viewed as a circle by increasing the number of corners.

(4) According to the present invention, in the touch panel according to any one of the items (1) to (3), in a detection electrode formation area in which the detection electrodes are formed, a ratio of an area of the plurality of holes to an area of the detection electrodes may be equal to or larger than 2/3 and equal to or smaller than 3/2.

(5) According to the present invention, in the touch panel according to any one of the items (1) to (4), distances between centers of the respective adjacent polygons may be equal to each other.

(6) According to the present invention, the touch panel according to any one of the items (1) to (5), may further include a shield electrode which is an electrode in which the plurality of holes shaped into the polygons are formed outside of a display area in which the detection electrodes are formed.

(7) According to the present invention, there may be provided a liquid crystal display device, including: the touch panel according to any one of the items (1) to (6); pixel electrodes that form an electric field with the scanning electrodes as counter electrodes; and liquid crystal having an orientation controlled by the electric field.

(8) Also, according to the present invention, there is provided a touch panel, including: a plurality of scanning electrodes; a plurality of detection electrodes that are formed to intersect with the plurality of scanning electrodes, one or a plurality of layers being disposed between the plurality of detection electrodes and the plurality of scanning electrodes, a plurality of holes that are arrayed apart from each other on each of the detection electrodes, and shaped into polygons each shaped to have five or more corners in a plan view; and a plurality of dummy electrodes that are formed between the respective adjacent detection electrodes, made of the same material as that of the detection electrode, and electrically isolated from each other, in which the plurality of dummy electrodes are shaped into polygons each having five or more corners in a plan view.

According to the present invention, as compared with the touch panel or the liquid crystal display device which does not provide the above configurations, the reflection of light and the generation of moiré on the polygonal holes in the detection electrodes and the side surfaces of the dummy electrodes are suppressed. For that reason, the prevention of the visibility of the image displayed through the touch panel from being deteriorated can be realized.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded perspective view of a liquid crystal display device having a touch panel according to an embodiment of the present invention;

FIG. **2** is a schematic cross-sectional view taken along a line II-II of the liquid crystal display device illustrated in FIG. **1**;

FIG. **3** is a partially enlarged view of an area III of the touch panel illustrated in FIG. **1**;

FIG. **4** is a partially enlarged view of an area IV of the touch panel illustrated in FIG. **3**;

FIG. **5** is a partially enlarged view illustrating one modification of the touch panel according to this embodiment in the same viewing field as that in FIG. **4**;

FIG. **6** is a partially enlarged view illustrating another modification of the touch panel according to this embodiment in the same viewing field as that in FIG. **4**;

FIG. **7** is a partially enlarged view illustrating still another modification of the touch panel according to this embodiment in the same viewing field as that in FIG. **4**;

FIG. **8** is a partially enlarged view illustrating yet another modification of the touch panel according to this embodiment in the same viewing field as that in FIG. **4**;

FIG. **9** is a partially enlarged view illustrating a further modification of the touch panel according to this embodiment in the same viewing field as that in FIG. **4**;

FIG. **10** is a partially enlarged view illustrating a still further modification of the touch panel according to this embodiment in the same viewing field as that in FIG. **4**;

FIG. **11** is a partially enlarged view of an area XI in the touch panel illustrated in FIG. **1**; and

FIG. **12** is a partially enlarged view of an area XII in the touch panel illustrated in FIG. **1**.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, a touch panel and a display device according to this embodiment will be described with the example of a liquid crystal display device **1** with reference to the accompanying drawings. For facilitation of understanding the characteristics, the drawings referred to in the following description may illustrate characteristic portions in an enlarged manner for convenience, and size ratios of the respective components are not always identical with actual size ratios. Also, materials and the like exemplified in the following description are exemplary, and the respective components may be made of materials different from the exemplary materials, and can be changed without departure from the spirit thereof.

FIG. **1** is an exploded perspective view of the liquid crystal display device **1** having a touch panel according to an embodiment of the present invention. As illustrated in FIG. **1**, the liquid crystal display device **1** includes a liquid crystal display panel **33**, and a front panel **46** having a display area D and a non-display area E. For convenience of description, a partial configuration of the liquid crystal display device **1** is omitted from FIG. **1**.

The liquid crystal display panel **33** is, for example, a liquid crystal display panel of an IPS (In-Plane Switching) system, and includes a first substrate **10** and a touch panel **42**. An area corresponding to the non-display area E on an upper surface **10***a* of the first substrate **10** is connected with a first flexible circuit board **2***a*, and also provided with a driver IC (integrated circuit) **3**. The driver IC **3** is arranged on an upper side of the first substrate **10** for receiving image data from an external of the liquid crystal display device **1** through the first flexible circuit board **2***a*. The driver IC **3** receives image data, and supplies a voltage signal to be applied to scanning electrodes (counter electrodes) **30** and pixel electrodes **34** to be described later through common wiring **58** for respective pixels.

The touch panel **42** includes the plural scanning electrodes **30**, a second substrate **12**, and plural detection electrodes **38**. The scanning electrodes **30** are disposed to extend at intervals from each other in a direction X in an area corresponding to the display area D on the upper surface **10***a* of the first substrate **10**. Also, the plural scanning electrodes **30** and the plural detection electrodes **38** extend to intersect with each other through one or a plurality of layers.

The second substrate **12** is arranged over an upper side of the first substrate **10**. In an area corresponding to the display area D on an upper surface **12***a* of the second substrate **12**, for example, the plural detection electrodes **38** extending in a direction Y are disposed at intervals from each other. The direction Y has only to intersect with a direction X, but it is preferable that the direction Y is orthogonal to the direction X.

Respective ends of the plural detection electrodes **38** formed in the area corresponding to the display area D in the direction Y are connected to terminals **40**, and an end of the detection electrode **38** formed in the area corresponding to the non-display area E in the direction Y is connected to a shield terminal **41**. Also, dummy electrodes **39** are formed between the respective adjacent detection electrodes **38**. The detailed configurations of the detection electrodes **38** and the dummy electrodes **39** will be described later.

The area corresponding to the non-display area E on the upper surface **12***a* of the second substrate **12** is connected with a second flexible circuit board **2***b*. The second flexible circuit board **2***b* is disposed for electric connection between the detection electrodes **38** and an external device, and a part of the second flexible circuit board **2***b* is connected to the first flexible circuit board **2***a*.

The front panel **46** is arranged on an upper side of the second substrate **12**. The front panel **46** is a member for protecting the liquid crystal display panel **33**. The display area D of the front panel **46** has a translucency, and a lower surface of the non-display area E is covered with a black matrix BM.

Subsequently, a configuration of the display area D in the liquid crystal display device **1** will be described in detail. FIG. **2** is a schematic cross-sectional view taken along a line II-II of the liquid crystal display device **1** illustrated in FIG. **1**.

The first substrate **10** is an insulating substrate made of, for example, glass, and a circuit layer **11**, the scanning electrodes **30**, and the pixel electrodes **34** are formed on the upper surface **10***a* of the first substrate **10** in the stated order.

The circuit layer **11** is a layer on which thin film transistors **18**, a first insulating film (gate insulating film) **22**, and electric wiring not shown are formed, and disposed to drive the pixel electrodes **34**. The thin film transistors **18** are disposed on the first substrate **10** for respective pixels P. Each of the thin film transistors **18** includes, for example, a polysilicon semiconductor layer **20**, the first insulating film **22**, a gate electrode **24**, a second insulating film **25**, a source electrode **26**, and a drain electrode **28**.

An upper side of the thin film transistor **18** is covered with a third insulating film (flattening film) **29**. The flattening film **29** is a layer made of an insulating material, and formed between the first substrate **10** and the pixel electrodes **34**, to thereby electrically isolate between the adjacent thin film transistors **18** or between the thin film transistors **18** and the pixel electrodes **34**.

The scanning electrodes **30** are formed over the flattening film **29**, and the pixel electrodes **34** are formed over upper

sides of the scanning electrodes **30** through a fourth insulating film **32**. The pixel electrodes **34** are electrodes formed for the respective pixels P for the purpose of driving liquid crystal **36** which will be described later. In this embodiment, the pixel electrodes **34** are located closer to the second substrate **12** side than the scanning electrodes **30**. However, the positional relationship may be reversed. The pixel electrodes **34** are connected to the thin film transistor **18** through contact holes **34***a*.

The second substrate **12** is arranged over the pixel electrodes **34** through a first oriented film **35***a*, the liquid crystal **36**, and a second oriented film **35***b*. With the above configuration, the pixel electrodes **34** each form an electric field in cooperation with the corresponding scanning electrode **30** as the counter electrode. An orientation of the liquid crystal **36** is controlled by an electric field generated between the scanning electrodes **30** and the pixel electrodes **34**.

The second substrate **12** is, for example, a color filter substrate, and has a color filter or a black matrix not shown formed thereon. The detection electrodes **38** and the dummy electrodes **39** that will be described later are formed over the second substrate **12**, and the front panel **46** is stuck on the detection electrodes **38** and the dummy electrodes **39** through an adhesion layer **44**.

Hereinafter, a configuration of the detection electrodes **38** and the dummy electrodes **39** will be described in detail. FIG. **3** is a partially enlarged view of an area III of the touch panel **42** illustrated in FIG. **1**. For convenience of description, illustrations other than the detection electrodes **38** and the dummy electrodes **39** are omitted in FIG. **3**. The detection electrodes **38** are electrodes for detecting whether the front panel **46** is touched from the external, or not based on the difference of capacitance between the detection electrodes **38** and the scanning electrodes **30**.

If areas in which the detection electrodes **38** are formed are detection electrode formation areas **138**, the detection electrodes (the detection electrode formation areas **138**) extend in the direction Y, and the plural detection electrodes **38** adjacent to each other in the direction X are aligned at intervals from each other. Also, the detection electrodes **38** are made of, for example, a translucent conductive material such as ITO (indium tin oxide).

The plural dummy electrodes **39** are electrodes which are formed between the respective adjacent detection electrodes **38**, made of the same material of the detection electrodes **38**, and electrically isolated from each other. When an area in which the plural dummy electrodes **39** are formed between the respective detection electrodes **38** is a dummy electrode formation area **139**, the dummy electrode formation area **139** extends in the direction Y, and fills a space between the respective adjacent detection electrodes **38**.

FIG. **4** is a partially enlarged view of an area IV of the touch panel **42** illustrated in FIG. **3**. For convenience of description, illustrations other than the detection electrodes **38**, the dummy electrodes **39**, and the pixels P are omitted in FIG. **4**. As illustrated in FIG. **4**, in the detection electrodes **38**, plural pentagonal holes **38***b* each shaped to have five corners **38***a* in a plan view are arrayed at intervals from each other. The respective holes **38***b* are arrayed at given intervals and pitches in a zigzag pattern, and arrayed regularly so that distances between a center of one hole **38***b* and respective centers of six holes **38***b* adjacent to one hole **38***b* are identical with each other. The number of corners **38***a* has only to be five or more, and the holes **38***b* are each formed into a polygonal shape having five or more corners **38***a* in a plan view. With the above configuration, at least a part of respective sides **38***c* of the holes **38***b* is not arrayed in parallel to an outer periphery P_1 of the pixel P which is formed into a rectangular shape in a plan view, and extends in a direction intersecting with the outer periphery P_1.

The respective shapes of the plural dummy electrodes **39** formed in the dummy electrode formation area **139** have the same polygonal shape as that of the holes **38***b* in the detection electrodes **38**. Specifically, the dummy electrodes **39** each have five corners **39***b* and five sides **39***c* as with the holes **38***b*. The "same polygonal shape" in this embodiment includes not only the completely identical polygonal shape, but also a shape deviated from the identical shape within the margin of error due to a manufacturing process.

As compared with the touch panel or the liquid crystal display device having the detection electrodes in which rectangular holes or grooved holes are formed, in the touch panel **42** and the liquid crystal display device **1** configured as described above in this embodiment, the respective sides **38***c* of the holes **38***b* of the detection electrodes **38** and the outer periphery P_1 of the pixels P, and the respective sides **39***c* of the dummy electrodes **39** and the outer periphery P_1 of the pixels P are prevented from being arranged in parallel to each other.

For that reason, as compared with the touch panel and the liquid crystal display device with no provision of the above configuration, the light emission from the pixels P is prevented from being reflected from the respective sides **38***c* of the detection electrodes **38** and the respective sides **39***c* of the dummy electrodes **39**, and advancing in the same direction. As a result, the patterns of the detection electrodes **38** and the dummy electrodes **39** are prevented from being visible from the outside of the touch panel **42**. Also, because the respective sides **38***c* of the detection electrodes **38** and the respective sides **39***c* of the dummy electrodes **39** are prevented from being successively arranged in parallel to each other, the generation of moiré can be suppressed.

With the above configuration, the touch panel **42** and the liquid crystal display device **1** according to this embodiment can realize the prevention of the visibility of the image displayed through the touch panel **42** from being deteriorated.

Also, because the shape of the holes **38***b* of the detection electrodes **38** are polygonal in the plan view, the light reflected on the side surfaces of the holes **38***b* is prevented from being focused on one point. For that reason, a difference in the visibility between the detection electrodes **38** and the dummy electrode formation area **139** is suppressed.

It is preferable that the detection electrodes **38** and the dummy electrodes **39** are formed through photolithography. When the detection electrodes **38** and the dummy electrodes **39** are formed by photolithography, the pattern becomes higher in definition, and the above-mentioned effects can be further obtained.

It is preferable that a radius d_1 (radius d_1 of the dummy electrodes **39**) of the holes **38***b* of the detection electrodes **38** is equal to or larger than 5 μm, and equal to or smaller than 250 μm. When the radius d_1 is equal to or larger than 5 μm, and equal to or smaller than 250 μm, the holes **38***b* of the detection electrodes **38** and the dummy electrodes **39** are prevented from being viewed, and a precision of the shapes of the holes **38***b* and the dummy electrodes **39** in the plan view can be kept.

Also, it is preferable that a distance d_2 (a distance d_2 between the respective adjacent dummy electrodes **39**) between holes **38***b* of the respective adjacent detection electrodes **38** is formed with a size within a processable range and a size preventing the visibility. Specifically, it is preferable that the distance d_2 is equal to or larger than 5 μm,

and equal to or smaller than 250 μm. When the distance d_2 is equal to or larger than 5 μm, and equal to or smaller than 250 μm, the visibility of the holes **38***b* of the detection electrodes **38** and the dummy electrodes **39** can be prevented, and an electric resistance of the detection electrodes **38** can be suppressed.

Also, it is preferable that the distance d_2 (distance d_2 between the respective adjacent dummy electrodes **39**) between the holes **38***b* of the respective adjacent detection electrodes **38**, and a length L_1 of long sides and a length L_2 of short sides of the pixels P in the plan view are different from each other. Since the touch panel **42** and the liquid crystal display device **1** according to this embodiment have the above configuration, positional relationships between the respective sides **38***c* of the holes **38***b* and the outer periphery P_1 of the pixels P, and between the respective sides **39***c* of the dummy electrodes **39** and the outer periphery P_1 of the pixels P suppress the generation of moiré.

Also, it is preferable that the plural holes **38***b* of the detection electrodes **38**, and the plural dummy electrodes **39** have a uniform contiguous array. Specifically, if a boundary between the detection electrode formation areas **138** and the dummy electrode formation area **139** is a boundary B, shapes S formed by the holes **38***b* and the dummy electrodes **39** adjacent to each other across the boundary B have the same polygonal shape as that of the holes **38***b* and the dummy electrodes **39** in the plan view. Specifically, on the boundary B, a shape of each detection electrode **38** corresponding to a part (specifically, substantially half thereof) of the hole **38***b*, and the dummy electrode **39** of a shape corresponding to the remaining part of the hole **38***b* are arranged in a complementary manner to arrange a boundary structure (shape S).

With the above configuration, the polygonal shapes in the plan view which are configured by the holes **38***b* and the dummy electrodes **39**, are contiguously and uniformly arrayed from the detection electrode formation areas **138** to the dummy electrode formation area **139** (The shapes S, the holes **38***b*, and the dummy electrodes **39** are arrayed at pitches common to each other, and array pitches of the polygonal shape in the plan view are maintained by the shapes S.) With the provision of this configuration, as illustrated in FIG. **4**, an outer periphery **38***d* of each detection electrode **38** on the dummy electrode **39** side is not linear, and a part of the outer periphery **38***d* configures the shape S.

Since the touch panel **42** and the liquid crystal display device **1** according to this embodiment have the above configuration, light from the pixels P is prevented from being reflected in one direction in the outer periphery **38***d* of the detection electrodes **38**. For that reason, the visibility of the boundary B can be prevented.

Also, it is preferable that an area **38***d_1* extending from the boundary B toward each hole **38***b* in the outer periphery **38***d* is curved. Since the curved area **38***d_1* is formed in the outer periphery **38***d*, an interference of light in the outer periphery **38***d* is suppressed. The area **38***d_1* can be curved by adjusting a condition of photolithography and an etching condition in the formation of the detection electrodes **38** and the dummy electrodes **39**.

Also, it is preferable that a ratio of a total of areas of the plural holes **38***b* (including the part of the plural holes **38***b* of the boundary structure) to an area of the detection electrodes **38** is equal to or larger than 2/3, and equal to or smaller than 3/2 in the detection electrode formation areas **138**. Also, it is further desirable that the area of the detection electrodes **38** in the detection electrode formation areas **138** is set to be equal to or larger than 0.9 times, and equal to or smaller than 1.1 times of the total area of the holes **38***b* formed in the detection electrodes **38**.

To be more specific, the detection electrode formation areas **138** are configured by the detection electrodes **38** and the holes **38***b*, and if the ratio of the total of the areas of the plural holes **38***b* to the area of the detection electrodes **38** falls within the above range. As a result, the ratio of the area of the detection electrodes **38** and the holes **38***b* in the detection electrode formation areas **138** falls within a range of from 3:2 to 2:3.

Also, because the planar shape of the holes **38***b* is equal to the planar shape of the dummy electrodes **39**, the ratio of the total of the areas of the dummy electrodes **39** to the area of the detection electrodes **38** per the same area is also equal to or larger than 2/3, and equal to or smaller than 3/2 with the provision of the above configuration.

With the above configuration, an area ratio of the detection electrodes **38** and the dummy electrodes **39** within the same area ranges within a given range from 1:1. As a result, in the touch panel **42** and the liquid crystal display device **1** according to this embodiment, a difference of the visibility is hardly generated as compared with the touch panel and the liquid crystal display device with no provision of the above configuration. For that reason, a difference in shading between the detection electrodes **38** and the dummy electrode formation area **139** is hardly visible, and the prevention of the visibility of the image displayed through the touch panel **42** from being deteriorated can be realized.

Also, it is preferable that if distances between centers c_1 of the respective adjacent holes **38***b*, and distances between centers c_2 of the respective adjacent dummy electrodes **39** are set to a distance d_3, the distance d_3 in the respective holes **38***b* is equal to the distance d_3 in the respective dummy electrodes **39**.

With the above configuration, the holes **38***b* are arranged in each detection electrode **38** in a closest manner, and the dummy electrodes **39** are arranged in the dummy electrode formation area **139** in the closest manner. For that reason, in the touch panel **42** and the liquid crystal display device **1** according to this embodiment, the area of the detection electrodes **38**, and the ratio of the dummy electrodes **39** to the dummy electrode formation area **139** are easily adjustable, as compared with the touch panel and the liquid crystal display device with no provision of the above configuration. Also, because the distances between the respective adjacent holes **38***b* are equal to each other, the electric resistance in the detection electrodes **38** can be suppressed.

Hereinafter, modifications of the touch panel **42** according to this embodiment will be described. FIG. **5** is a partially enlarged view illustrating one modification of the touch panel **42** according to this embodiment in the same viewing field as that in FIG. **4**. As illustrated in FIG. **5**, the holes **38***b* may be each shaped into a hexagon having six corners **38***a* in a plan view. Likewise, the dummy electrodes **39** may be each shaped into a hexagon having six corners **39***a*. With the above configuration, at least four sides **38***c* of each hole **38***b*, and at least four sides **39***c* of each dummy electrode **39** are not arranged in parallel to the outer periphery P_1 of the pixels P, and extend in directions intersecting with the outer periphery P_1.

For that reason, in the touch panel **42** and the liquid crystal display device **1** according to this embodiment, the respective sides **38***c* of the holes **38***b* and the outer periphery P_1 of the pixels P, and the respective sides **39***c* of the dummy electrodes **39** and the outer periphery P_1 of the pixels P are prevented from being arranged in parallel to each other, as

compared with the touch panel and the liquid crystal display device with no provision of the above configuration. For that reason, the generation of moiré is suppressed, and the prevention of the visibility of the image displayed through the touch panel **42** from being deteriorated can be realized.

FIG. **6** is a partially enlarged view illustrating another modification of the touch panel **42** according to this embodiment in the same viewing field as that in FIG. **4**. As illustrated in FIG. **6**, the holes **38***b* and the dummy electrodes **39** may be shaped into heptagons having seven corners **38***a* and **39***a*, respectively. Since the holes **38***b* and the dummy electrodes **39** have the polygonal shapes having odd-numbered corners **38***a* and **39***a* in the plan view, the number of respective sides **38***c* of each hole **38***b* which are parallel to the outer periphery P_1 of the pixel P is at most one.

Likewise, the number of respective sides **39***c* of each dummy electrode **39** which are parallel to the outer periphery P_1 of the pixel P is at most one. For that reason, in the touch panel **42** and the liquid crystal display device **1** according to this embodiment, the generation of moiré is suppressed as compared with the touch panel and the liquid crystal display device with no provision of this configuration. As a result, the prevention of the visibility of the image displayed through the touch panel **42** from being deteriorated can be realized.

FIG. **7** is a partially enlarged view illustrating still another modification of the touch panel **42** according to this embodiment in the same viewing field as that in FIG. **4**. As illustrated in FIG. **7**, the holes **38***b* and the dummy electrodes **39** may be shaped into octagons having eight corners **38***a* and **39***a*, respectively.

FIG. **8** is a partially enlarged view illustrating yet another modification of the touch panel **42** according to this embodiment in the same viewing field as that in FIG. **4**. The holes **38***b* and the dummy electrodes **39** illustrated in FIG. **8** are shaped into dodecagons having 12 corners **38***a* and **39***a*, respectively. If the number of corners **38***a* and **39***a* is thus five or more, the number is not limited to the above example, and may increase more.

FIG. **9** is a partially enlarged view illustrating a further modification of the touch panel **42** according to this embodiment in the same viewing field as that in FIG. **4**. The holes **38***b* and the dummy electrodes **39** in FIG. **9** are each viewed as a circle in the plan view by increasing the number of corners **38***a* and **39***a* (for example, increasing the number of corners **38***a* and **39***a* to 20 or more). In the touch panel **42** and the liquid crystal display device **1** according to this embodiment, with the provision of the above configuration, portions in which the respective sides **38***c* of the holes **38***b* and the outer periphery P_1 of the pixels P, and the respective sides **39***c* of the dummy electrodes **39** and the outer periphery P_1 of the pixels P are lined up in parallel to each other can be minimized as compared with the touch panel or the liquid crystal display device with no provision of the above configuration. For that reason, the patterns of the detection electrodes **38** and the dummy electrodes **39** can be viewed, and the generation of moiré can be suppressed. The plural holes **38***b* of the detection electrodes **38** and the plural dummy electrodes **39** have only to be each shaped into the polygon having five or more corners in the plan view, and the number of corners may be different between the holes **38***b* of the detection electrodes **38** and the dummy electrodes **39**. Also, in this case, the shapes S may be arranged and formed so that array pitches of the holes **38***b* and the dummy electrodes **39** are maintained.

The array of the plural holes **38***b* of the detection electrodes **38**, and the plural dummy electrodes **39** has been described above. The holes **38***b* and the dummy electrodes **39** may be arrayed except for in the zigzag array. FIG. **10** is a partially enlarged view illustrating a still further modification of the touch panel **42** according to this embodiment in the same viewing field as that in FIG. **4**. As illustrated in FIG. **10**, the holes **38***b* and the dummy electrodes **39** may not be arrayed in the closest manner.

Subsequently, a configuration of the touch panel **42** in the non-display area E will be described in detail. FIG. **11** is a partially enlarged view of an area XI in the touch panel **42** illustrated in FIG. **1**, and FIG. **12** is a partially enlarged view of an area XII in the touch panel **42** illustrated in FIG. **1**.

In the non-display area E, a shield electrode **47** connected to the shield terminal **41** is formed to extend in the direction Y. The shield electrode **47** is an electrode configured to include a first area **48** which is an area of the display area D side, and a second area **49** which is an area outside of the first area **48**. The first area **48** is formed along a boundary F between the display area D and the non-display area E. Also, the first area **48** is formed over the overall area corresponding to the non-display area E.

In the first area **48**, as with the detection electrodes **38**, holes **48***b* having the same shape as that of the holes **38***b* in the plan view are regularly formed. With this configuration, the first area **48** has the same shape as that of the detection electrodes **38** in the plan view.

In the touch panel **42** and the liquid crystal display device **1** according to this embodiment, the shield electrode **47** (the first area **48**) having the plural holes **48***b* are formed along the boundary F in an area corresponding to the non-display area E of the touch panel **42**. As a result, a shading difference within the non-display area E when the non-display area E is viewed from the outside of the touch panel **42** can be suppressed.

The embodiments of the present invention have been described above, but the present invention is not limited to the above-mentioned embodiments. For example, the configuration described in the above-mentioned embodiments may be replaced with a substantially identical configuration, a configuration having the same function effect, or a configuration that can achieve the identical purpose.

For example, in this embodiment, the touch panel **42** of the present invention is applied to the liquid crystal display device **1** of the in-cell system using the counter electrodes to which a voltage common to the plural pixels adjacent to each other in the direction X is applied as the scanning electrodes **30**. Alternatively, the touch panel **42** of the present invention is not limited to the in-cell system, but can be applied to an on-cell system in which both of the scanning electrodes **30** and the detection electrodes **38** are formed over the second substrate **12**, or a system in which a substrate on which the scanning electrodes and the detection electrodes are formed is put on the display device. Also, the touch panel **42** of the present invention may be applied to the display device (for example, an organic EL (electro luminescence) display device) other than the liquid crystal display device **1**.

While there have been described what are at present considered to be certain embodiments of the invention, it will be understood that various modifications may be made thereto, and it is intended that the appended claims cover all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A touch panel, comprising:

a plurality of scanning electrodes;

a plurality of detection electrodes that are formed to intersect with the plurality of scanning electrodes, one

or a plurality of layers being disposed between the plurality of detection electrodes and the plurality of scanning electrodes;

a plurality of holes that are arrayed apart from each other on each of the plurality of detection electrodes, and shaped into polygons each shaped to have five or more corners in a plan view; and

a plurality of dummy electrodes that are formed between the respective adjacent detection electrodes, made of the same material as that of the detection electrode, and arrayed apart from each other,

wherein a surface shape of the plurality of dummy electrodes have the same polygonal shape as that of the hole of the detection electrodes, and

the surface shape of the plurality of dummy electrodes are not the same as that of the detection electrodes.

2. The touch panel according to claim **1**,

wherein the plurality of holes shaped into the polygons and arrayed on the detection electrodes, and the plurality of dummy electrodes form a uniform contiguous array.

3. The touch panel according to claim **1**,

wherein the planar view shape of the polygons is viewed as a circle by increasing the number of corners.

4. The touch panel according to claim **1**,

wherein in a detection electrode formation area in which the detection electrodes are formed, a ratio of an area of the plurality of holes to an area of the detection electrodes is equal to or larger than 2/3 and equal to or smaller than 3/2.

5. The touch panel according to claim **1**,

wherein distances between centers of the respective adjacent polygons are equal to each other.

6. The touch panel according to claim **1**, further comprising a shield electrode which is an electrode in which the plurality of holes shaped into the polygons are formed outside of a display area in which the detection electrodes are formed.

7. A liquid crystal display device, comprising:

the touch panel according to claim **1**;

pixel electrodes that form an electric field with the scanning electrodes as counter electrodes; and liquid crystal having an orientation controlled by the electric field.

8. A touch panel, comprising:

a plurality of scanning electrodes;

a plurality of detection electrodes that are formed to intersect with the plurality of scanning electrodes, one or a plurality of layers being disposed between the plurality of detection electrodes and the plurality of scanning electrodes;

a plurality of holes shaped that are arrayed apart from each other on each of the plurality of detection electrodes, and shaped into polygons each shaped to have five or more corners in a plan view; and

a plurality of dummy electrodes that are formed between the respective adjacent detection electrodes, made of the same material as that of the detection electrode, and arrayed apart from each other,

wherein a surface shape of the plurality of dummy electrodes are shaped into polygons each having five or more corners in a plan view, and

the surface shape of the plurality of dummy electrodes are not the same as that of the detection electrodes.

9. The touch panel according to claim **8**,

wherein an area of the hole shaped on the detection electrodes is same as that of the dummy electrode.

10. The touch panel according to claim **8**,

wherein the plurality of holes shaped into the polygons and arrayed on the detection electrodes, and the plurality of dummy electrodes form a uniform contiguous array.

11. The touch panel according to claim **8**,

wherein in a detection electrode formation area in which the detection electrodes are formed, a ratio of an area of the plurality of holes to an area of the detection electrodes is equal to or larger than 2/3 and equal to or smaller than 3/2.

12. The touch panel according to claim **8**,

wherein distances between centers of the respective adjacent polygons are equal to each other.

13. The touch panel according to claim **8**, further comprising a shield electrode which is an electrode in which the plurality of holes shaped into the polygons are formed outside of a display area in which the detection electrodes are formed.

14. A liquid crystal display device, comprising:

the touch panel according to claim **8**;

pixel electrodes that form an electric field with the scanning electrodes as counter electrodes; and

liquid crystal having an orientation controlled by the electric field.

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